CRANKCASE ANALYSIS FOR TWO-STROKE SPARK IGNITION ENGINE

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Crankcase of two-stroke spark ignition engine is an important part since it compresses the air fuel mixture before going into cylinder. Parameter inside crankcase such as pressure largely affects the performance of this engine. In this project, the simulation of flow inside of two-stroke engine had been carried out. The objective of this project is to simulate the visualization of crankcase flow process. The advantages of using CFD in this research are low cost and easy to apply compared to the laser. Before the main concept had been applied, COSMOS application is the one of the software that introduces to the basic of flow pattern in this research. After complete the entire tutorial this software, will proceed with the CFD application. CFD application was started by modeling the crankcase in three-dimensional in SOLIDWORK. After that, GAMBIT was use to generate grids before export to FLUENT for flow analysis. Crankcase model was simulated in motoring condition, which means no combustion or firing. As a result, pressure and contours inside the crankcase flow was observed. And found that the simulation results are slightly different from calculation.

ABSTRAK

Kotak engkol merupakan satu bahagian yang penting dalam engine pembakaran dalam dua lejang. Ia berfungsi untuk memampatkan campuran udara dan bahan api sebelum memasuki silinder. Parameter dalam kotak engkol umpamanya tekanan memberi kesan yang besar terhadap prestasi enjin ini. Dalam projek ini, simulasi terhadap aliran dalam kotak engkol bagi enjin dua lejang telah dilakukan. Objektif projek ini ialah untuk simulasi dan memerhatikan proses aliran dalam kotak engkol Kelebihan teknik analisis pengaliran dinamik dalam kajian ini merupakan analisis yang murah dan senang digunakan berbanding penggunaan laser. Sebelum mengaplikasikan konsep yang utama, aplikasi COSMOS merupakan perisian yang memperkenalkan asas proses aliran dalam kajian ini. Selepas tamat latihan tutorial dalam aplikasi ini, teknik analisis aliran dinamik akan diteruskan. Teknik analisis aliran dinamik dimulakan dengan memodelkan kotak engkol dalam tiga dimensi dalam perisian SOLIDWORK. Selepas itu, GAMBIT pula digunakan untuk menjana grid sebelum dieksport ke FLUENT untuk analisis aliran. Model kotak engkol disimulasikan dalam keadaan bermotor yakni tiada pembakaran. Hasilnya tekanan beserta kontur kelajuan aliran dalam kotak engkol dapat diperhatikan. Didapati tekanan dari simulasi mempunyai ralat berbanding nilai tekanan daripada kiraan.

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LIST OF SYMBOLS

Roman Symbols

A	_	Stroke
CR_{cc}	_	Crankcase compression ratio
d_b	_	Diameter of cylinder
$H(\theta)$	_	Piston position
L	_	Connecting rod length
P_s	_	Piston position
SE_v	_	Scavenging efficiency on volumetrically
SR_v	_	Scavenged ratio on volumetrically
TE_v	_	Trapping efficiency on volumetrically
V_{am}	_	Volume of air in the mixing zone
V_{as}	_	Air supplied /volume fresh air
V_{cc}	_	Crankcase volume
$V_p(\theta)$	_	Piston velocity
V_s	_	Swept volume
V_{ta}	_	Volume of air trapped
V_{ts}	_	Trapped swept volume

Greek Symbols

$k-\varepsilon$	_	Standard k-epsilon model
λ_d	_	Delivery ratio (or scavenge ratio)
η_{se}	_	Scavenging efficiency
η_{te}	_	Trapping efficiency
η_{ce}	_	Charging efficiency

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LIST OF ABBREVIATIONS

ATDC	After Top Dead Center
BC	Boundary Condition
BDC	Bottom Dead Center
CA	Crank Angle
CFD	Computational Fluid Dynamics
DAQ	Data Acquisition System
FLUENT	Computational Fluid Dynamics code software
IC	Internal Combustion
SAE	Society of Automotive Engineers
TDC	Top Dead Center

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The first two-stroke engine was invented by Sir Dugald Clerk (1900) in England at the end of 19^{th} century. The form of engine using crankcase compression for intake process, including the control of the timing and the area of the exhaust port, transfer and the inlet ports by the piston, was patented by Joseph Day (1891) in England. Same as today conventional two stroke cycle engine, the engine patented by Joseph Day was a three ports engine, where the intake ports used to suck air or mixture from the carburetor or air cleaner and been transfer to the combustion by the transfer port, while the third port is used as a exhaust port to allow burned gases exhausted to the atmospheric [10].

In a conventional two-stroke internal combustion engine, the vacuum caused by a piston moving away from the crankcase draws a mixture of fuel, air and oil into the crankcase through a one-way valve of timed induction mechanism such as a piston port or rotary valve. Crankcase of two-stroke spark ignition engine is an important part since it acts as a compressor to compress the air-fuel mixture before going into cylinder [8][16].

1.2 PROBLEM STATEMENT

Crankcase scavenged two-stroke gasoline engines suffer from fresh charge losses leading to poor fuel economy and it is a reason for large increases of hydro-carbon in the exhaust. In recent years, two-stroke engines have been re-evaluated in terms of improvements to the drawbacks, involving the in-cylinder fuel injection, exhaust catalysts, and control of the optimum port area [1][2].

Previously, there are only a few sources regarding the study of the crankcase for two-stroke spark ignition engine [3][4][5][6]. In addition, some other sources use formulas and calculations to determine the internal flow process of the crankcase. The accuracy of determined parameters are different compare to the actual engine running process. This project is to focus more detail on simulation of two-stroke spark ignition engine by using computational fluid dynamics (CFD) with motoring method and dynamic mesh approach to the crankcase. CFD codes are developed for the simulation of a wide variety of fluid flow process. They can be analyzed steady or unsteady flow, laminar or turbulence flow, flow in two or three dimensions and single or two phase flow [7]. The model was based on a single cylinder research engine and included features to simulate the motion of air-fuel and lubricant mixture inside the crankcase.

1.3 PROJECT OBJECTIVE

The objective of this project is to simulate the visualization of crankcase flow process for a single 30.5 cc two-stroke spark ignition (SI) engine.

1.4 PROJECT SCOPES

i. Literature review regarding the two-stroke spark ignition engine.
ii. Three dimensional CAD modeling and drawing.
iii. Familiar with usage of COSMOS FLOWORKS and FLUENT.
iv. Simulation with COSMOS FLOWORKS and FLUENT.

1.5 THESIS ORGANIZATION

This thesis consists of five chapter summarized as follows:

Chapter 2 is focus about the literature review of two-stroke spark ignition engine as general. Then, the detail of crankcase was mentioned in term of construction and function to the engine.
Chapter 3 consist of methodology of this research, flow chat and simulation set up processes. It is concentrate on the three-dimensional analysis by FLUENT in term of modeling, mesh generation, and define boundary conditions and simulation set up.

Chapter 4 includes the detail results and discussion on this research. The main focus is on the pressure distribution inside the crankcase. Besides, results from COSMOS also contain in this chapter for the initial flow trend observation. It also provided the visualization results for contours and vectors of velocity magnitude and static temperature.

Chapter 5 concludes the results provide some recommendations for future work regarding this research.

1.6 AUTHOR'S CONTRIBUTION

Determine the pressure distribution inside crankcase by build up the three-dimensional model and simulate using the dynamic mesh approaches. Visualization of crankcase velocity characteristics contributes to the study in this research at different crank angle.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to provide a review of past research effort related to crankcase analysis of two-stroke spark ignition engine. This chapter will include all the important information regarding the internal combustion engine, two-stroke engine and finally the crankcase of two-stroke engine. Generally, the crankcase is one of the important part in two-stroke spark ignition engine, not only mounted the crankshaft assembly, but also provide the vacuum for intake stroke purpose.

2.2 INTERNAL COMBUSTION ENGINE

The internal combustion (IC) engine is a heat engine that converts chemical energy in a fuel into mechanical energy, usually made available on a rotating output shaft. Chemical energy of the fuel is first converted to thermal energy by means of combustion of oxidation with air inside the engine. This thermal energy raises the temperature and pressure of the gases within the engine, and the high-pressure gas then expands against the mechanical mechanisms of the engine [6].

An internal combustion engine can work on any one of the following cycles [7][8]:

a. Constant volume or Otto cycle.
b. Constant pressure or Diesel cycle.
c. Dual combustion cycle.

Constant volume or Otto cycle – heat is supplied at constant volume. Petrol, gas, light oil engine works on this cycle. In the case of petrol engine, the proper mixing of petrol and air takes place in the carburetor, which is situated outside the engine cylinder. The proportionate mixture is drawn into the cylinder during the suction stroke [8][9].

Constant pressure or Diesel cycle – only air is drawn into the engine cylinder during suction stroke, this air gets compressed during the compression stroke and its pressure and temperature increase by a considerable amount. Just before the end of the stroke a metered quantity of fuel under pressure adequately more than that developed in the engine cylinder is injected in the fine sprays by injector. Heavy oil engines make use of this cycle [9][8].

Dual combustion cycle – also called the semi-diesel cycle. Heat is added partly at constant volume and partly at constant pressure. In this cycle only air is drawn into the engine cylinder during suction stroke. The air is then compressed in hot chamber at the end of the cylinder during the compression stroke to a pressure of about 26 bar. The heat compressed air together with heat of combustion chamber ignites the fuel. The fuel is injected into the cylinder just before the end of compression stroke when it ignites immediately. The application of this cycle is heavy oil engines [8][9].

2.2.1 Background of Two-Stroke Cycle Engine

Some sources claim that two-Stroke engines were produced by Butler and Roots (1887) based on a crankcase scavenged, piston controlled intake, transfer, and exhaust port patent ultimately issued to F.W.C. Cock in England in 1892, and owned by Joseph Day. From 1928 to 1948, General Motors Research Laboratories under CF Kettering made a serious effort to develop a two-stroke powered vehicle. The engine configuration was also an inverted U-type patterned [11].

Some of the early applications of the two-stroke engine include the first engine that produced by Edward Butler in 1887 and by J.D.Roots, in the form of the Day crankcase compression type, in 1892. Usually this kind of engine was used in motorcycle, scooters, small chainsaw engine, light aircraft etc. Besides the small power output usage, the two-stroke cycle engines also being applied in the marine diesel engine due to its simplicity of constructions, low weight and higher power output [10].

2.3 TWO-STROKE ENGINE

The two-stroke engine employs the crankcase as well as the cylinder to achieve all the elements of the Otto cycle in only two strokes of the piston [7][9][10].

In a conventional two-stroke internal combustion engine, the vacuum caused by a piston moving away from the crankcase draws a mixture of fuel, air and oil into the crankcase through a one-way valve of timed induction mechanism such as a piston port or rotary valve. Increased pressure produced by the piston moving toward crankcase forces the mixture of fuel, air and oil into piston cylinder on the side of the piston away from crankcase and, therefore, into combustion chamber, which is at the portion of the piston cylinder that is most distant from the crankcase, because such carbureted fuel cannot escape through the one-way valve or a now closed induction mechanism [9][10].

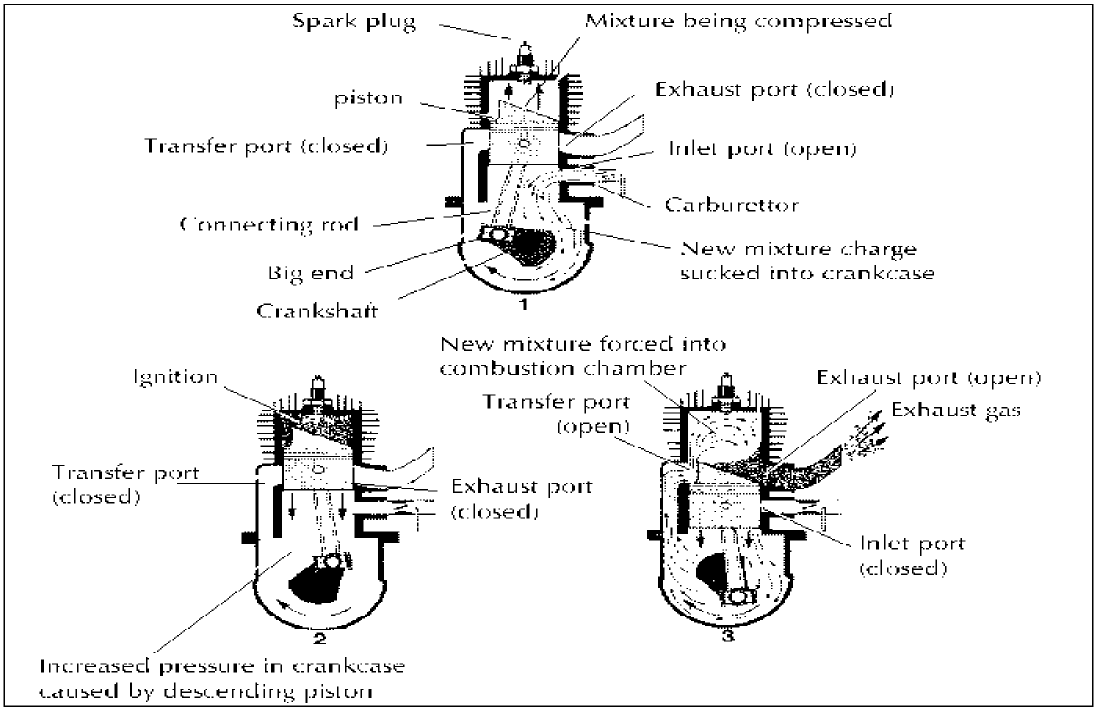

Figure 2.1: Two-stroke cycle engine [12]

In the single cylinder two-stroke spark ignition engine, there are two main of movement of piston that differentiates from other engine that is compression stroke and power stroke. For the intake process, the air-fuel mixture is first drawn into the crankcase by the vacuum created during the upward stroke of the piston. The illustrated engine features a poppet intake valve, however many engines use a rotary value incorporated into the crankshaft [7][9][13].

During the downward stroke, the poppet valve is closed by the increased crankcase pressure. The fuel mixture is then compressed in the crankcase during the remainder of the stroke [7].

Toward the end of the stroke, the piston exposes the intake port, allowing the compressed fuel/air mixture in the crankcase to escape around the piston into the main cylinder. This expels the exhaust gasses out the exhaust out the exhaust port, usually located on the opposite side of the cylinder [7].

The piston then rises, driven by flywheel momentum, and compresses the fuel mixture. (at the same time, another intake stroke is happening beneath the piston). At the top of the stroke, the spark plug ignites the fuel mixture. The burning fuel expands, driving the piston downward to complete the cycle [7][10].

Inherent in the two-stroke cycle is the process of scavenging the burned gases from the engine cylinder with fresh charge. This gas exchange process has several consequences. First charging losses are inevitable. Under normal operation conditions in a typical two-stroke engine, about 20% of the fresh charge that enters the cylinder is lost due to short circuiting to the exhaust and results in very high hydrocarbon emissions and poor fuel economy [12].

2.3.1 Scavenging process

In two-stroke cycle engines, each outward stroke of the piston is a power stroke. In order to achieve this two-stroke, the fresh charge must be supplied to the cylinder at a high-enough pressure to displace the burned gases from previous cycle [14]. The operation of clearing the cylinder of burned gases and filling it with fresh mixture combination between intake and exhaust process is known as scavenging [1][14][12]. The design of port system either the intake or the exhaust ports of two-stroke spark ignition engine is very influential in the short-circuiting of fresh charge [14]. The short-circuiting phenomena are responsible for the lower fuel efficiency and high hydrocarbons emission.

Today, three main categories of scavenging process generally accepted:

- Cross scavenging
- Loop scavenging
- Uniflow scavenging

2.3.1.1 Cross scavenging

Cross scavenging is the simplest way of loading the cylinder with fresh charge. First, the system was designed the way that the piston head towards the cylinder head deflected the incoming gas jet. Thus the leading to the thermal problems with the piston, newer designs are consisting angular intake port areas. The burnt gases are pushed by the fresh charge towards the exhaust port. Since the exhaust port area is right in front of the intake port, there is the risk of direct charge loss in form of short-circuiting.

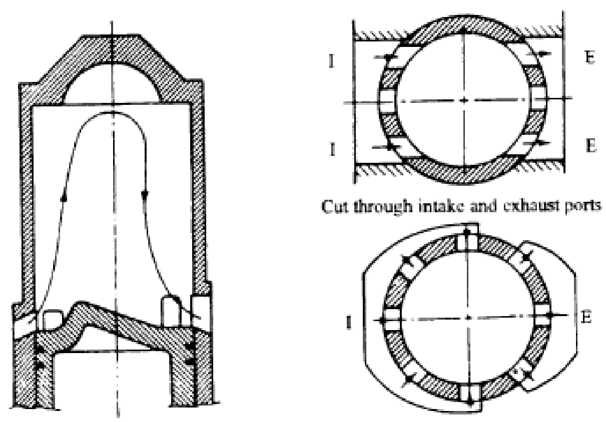

Figure 2.2 : Cross scavenging [15]

2.3.1.2 Loop scavenging

In loop scavenging system, the burnt gases leave the cylinder in reverse flow direction to the incoming fresh charge. There are two sub categories, which is MAN - loop scavenging and SCHNURLE – loop scavenging [10][15].